TRAINING BOOK

ENGLISH

05-0763 Revision 1

EASY-LASER®

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INTRODUCTION

Damalini AB

Damalini AB develops, manufactures and markets Easy-Laser® measurement and alignment equipment based on laser technology.

We have more than 25 years of experience from measurement tasks in the field and product development. We also provide measurement service, which means that we ourselves use the equipment we develop, and continuously improve it. Because of this we dare to call ourselves measurement specialists.

Do not hesitate to contact us about your measurement problems. Our expertise will help you solve it in an easy way.

Declaration of conformity

Equipment: Easy-Laser® product range

Damalini AB declares that the Easy-Laser® product range is manufactured in conformity with national and international regulations. The system complies with, and has been tested according to the following requirements:

CE

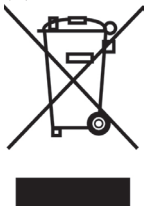
EMC Directive	2004/108/EG
Low Voltage Directive	2006/95/EC
Laser Classification	Europe: SS_EN 60825-1 USA: CFR 1040.10/11
RoHs Directive	2011/65/EU
WEEE Directive	2012/19/EU

The calibration of the equipment fully complies with ISO9001:2008 #7.6

For Bluetooth® devices: This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference

(2) this device must accept any interference received, including interference that may cause undesired operation.



Disposal of old electrical and electronic equipment (Applicable throughout the European Union and other European countries with separate collection programs)

This symbol, found on product or on its packing, indicates that this product should not be treated as household waste when disposed of. It should be handed over to an applicable collection point for the recycling of electrical and electronic equipment. By ensuring this product is disposed correctly, you will help to prevent potential negative consequences to the environment and human health. For more detailed information about the recycling of this product, please contact your local city office, household waste disposal service or the retail store where you purchased this product.

Quality certificate

Damalini AB is ISO 9001:2008 certified. Certificate number 900958.

Damalini AB confirm, that our products are produced according to applicable national and international regulations and standards. All components are checked before assembly and final products are tested in functionality and visually checked before delivery

The calibration of the equipment fully complies with ISO9001: 2008 #7.6

Limited warranty

This product is manufactured under Damalini's strict quality control system. Should the product fail within two (2) years from the date of purchase under normal usage conditions, Damalini will repair or replace the product free of charge.

1. Using new or refurbished replacement parts.
2. Exchange the product with a product that is new or which has been manufactured from new or serviceable used parts and is at least functionally equivalent to the original product.

Proof of purchase date should be confirmed, and sent together with a copy of the original purchase document.

Warranty is valid under normal usage described in the user's manual appended with the product. The warranty comprises failure on Easy-Laser® product that could be related to material and/or fabrication errors. The warranty is valid only in the country of purchase.

The warranty is not valid in the following cases:

- If the product is broken due to mishandling or incorrect operation
- If the product has been exposed to extreme temperature, calamity, chock or high voltage.
- If the product has been modified, repaired or disassembled by unauthorized personnel.

Compensation for possible damage due to failure on Easy-Laser® product is not included in the warranty. Freight cost to Damalini is not included in the warranty.

Note!

Before delivery of the product for warranty repair, it is the responsibility of the buyer to backup all data. Data recovery is not included in the warranty service and Damalini is not responsible for data that may be lost or damaged during transit or repair.

Lithium Ion battery limited warranty

Lithium ion batteries inevitably lose power during their lifetimes, depending on usage temperatures and the number of charging cycles. Therefore, the internal rechargeable batteries used in the E-series are not included in our general 2-year warranty. There is a 1 year warranty for the battery capacity not to fall below 70 % (a normal change means that the battery must have more than 70 % capacity after more than 300 charging cycles). A 2 year warranty applies if the battery becomes unusable because of a manufacturing fault or factors that Damalini AB could be expected to have control of, or if the battery displays abnormal loss of capacity in relation to use.

Extended warranty

Easy-Laser® Measurement and Alignment Systems meet the highest quality standards! For this reason, we have extended the warranty to you to a total of 3 years — free of charge!

The prerequisite for a warranty extension is that you register your system parts on the Internet within 6 months of purchase. The warranty period begins on the date of purchase. The warranty extension applies to all products in accordance with the Easy-Laser® Warranty requirements.

Safety precautions

Easy-Laser® is a laser instrument in laser class II with an output power less than 1 mW, which requires the following safety precautions:

- Never stare directly into the laser beam
- Never aim the laser beam at anyone else's eyes.

Note!

Opening the laser units can result in hazardous radiation, and will invalidate the manufacturer warranty.

If starting the machine to be measured would result in injuries, the possibility to unintentionally start it must be disabled before mounting the equipment, for example by locking the switch in the off position or removing the fuses. These safety precautions should remain in place until the measurement equipment has been removed from the machine.

Note!

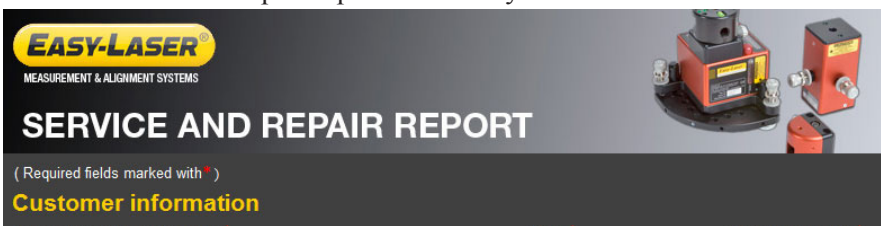
The system should not be used in explosive risk areas.

Service and calibration

Our Service centres will quickly assist you if your measurement system need to be repaired or when it is time for calibration.

Our main Service centre is located in Sweden. There are several local Service centres that are certified to carry out limited service and repair. Contact your local Service centre first before sending your equipment for service or repair. All Service centres are listed on our web site under Service and Calibration.

Before sending your measuring system to our main Service centre, please fill in the online Service and Repair report. www.easy-laser-service.com



Manuals as PDF

You can download our manuals in pdf format from our website. The pdf's are also available on the USB memory stick that is delivered with most systems.

EasyLink

The new version of our database program EasyLink is available on the USB memory stick that is delivered with most systems. You can always download the latest version from damalini.com>download>software.

Travelling with your measurement system

When travelling by airplane with your measurement system we strongly recommend that you check which rules apply for each airline company. Some companies/countries have limitations for checked baggage when it comes to items including batteries. For information about Easy-Laser® batteries, please see system unit details in the end of this manual. It is also good practice to remove the batteries from the equipment, when possible, e.g. D22, D23 and D75.

Compatibility

The E-series is not compatible with previous analogue units from the D-series. You can however continue to use previous brackets.

Disclaimer

Damalini AB and our authorized dealers will take no responsibility for damage to machines and plant as a result of the use of Easy-Laser® measurement and alignment systems.

Copyright

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We might change and correct the manual in later issues without further information. Changes to the Easy-Laser® equipment may also affect the accuracy of the information.

May 2014

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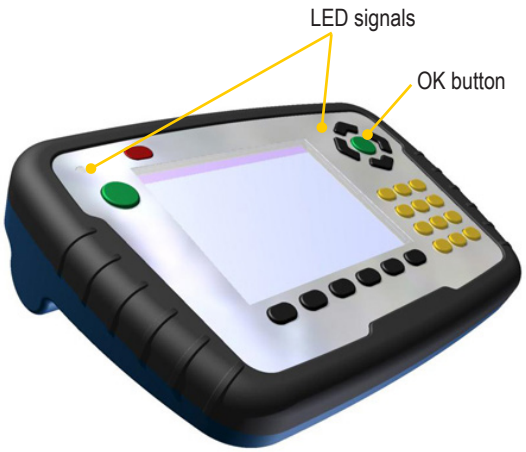
DISPLAY UNIT

We have three kinds of Display units, E51, E52 and E53.
Press and hold the On/Off button to reset the Display unit.

E51



E52

	E51	E52	E53
E420			*
E530		*	
E540		*	
E710	*		
E910	*		
E915	*		
E920	*		
E930	*		
E940	*		
E950	*		
E960	*		
E980			

E53

Note!

A good idea is to start the E53 Display unit **before** *starting the measuring units.*

Programs in the different systems

	E420	E530 E540	E710	E910 E915	E920	E930	E940	E950 A/B/C	E960 A/B	E980
Values	*	*	*	*	*	*	*	*	*	*
Horizontal	*	*	*		*	*	*	*	*	*
Vertical	*	*	*		*	*	*	*	*	*
Machine train (**)		*	*		*	*	*	*	*	*
Softfoot	*	*	*		*	*	*	*	*	*
Cardan			*		*	*	*	*	*	*
Straightness			*		*	*	*	*	*	*
Straightness Half					*	*	*	*	*	*
Straightness Fourpoints					*	*	*	*	*	*
Straightness Multipoints					*	*	*	*	*	*
Straightness Centre					*	*	*	*	*	*
Flatness			*		*	*	*	*	*	*
Twist			*		*	*	*	*	*	*
Spindle					*	*	*	*	*	*
Squareness					*	*	*	*	*	*
Flange flatness			*	*	*	*	*	*	*	*
Flange flatness section			*	*	*	*	*	*	*	*
Flange parallelism				*	*	*	*	*	*	*
Offset and Angle			*		*	*	*	*	*	*
BTA		*	*		*	*	*	*	*	*
Vibration		*	*		*	*	*	*	*	*

Navigation buttons

To navigate on the screen, use the navigation buttons. The selected icon is marked with a yellow frame. The navigation buttons are also used to move between the icons in a submenu and to change the values in the fields.

Function buttons

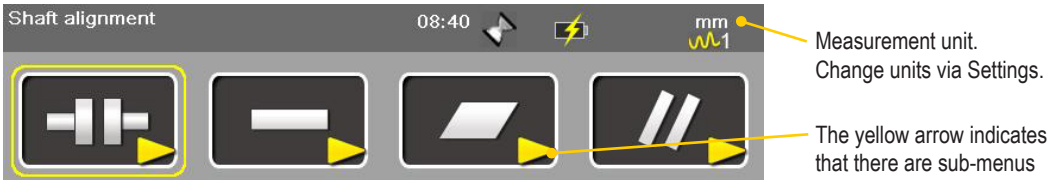
The icons above the function buttons change depending on which view is currently displayed on screen.

Note!

Some functionality differs depending on Display unit is used. For more information regarding LED lights and Battery, please see the manual that corresponds with your system.

Status bar

The Status bar contains additional information such as warning icon, current time and Bluetooth® connection.



There are also text messages regarding:

- The selected icon.
- Hints on what information you are expected to fill in.

Status bar icons

	Warning. Select the function button to get additional information regarding the warning.
	Warning. Displayed when the coordinates has been rotated in the detector. Go to Control panel to rotate coordinates.
	Display unit charging. Indicating that a power adaptor is plugged in.
	Hourglass. The Display unit is in the middle of a task.
	Peripheral. Indicates that a peripheral device is plugged in, such as a projector. *Not available for E420.*
	Bluetooth®. Indicates that the Bluetooth® functionality is activated. The number beside indicates the number of Bluetooth® units connected.
	Printing report on thermal printer. The thermal printer is optional equipment.
	Printing performed OK.
	Printing problem.

Screen dump

It is possible to take screen dumps of what is currently displayed on screen. You can e-mail the screen dump or use it for reports.

Take a screen dump

1. Press and hold the numeric button period (.) for 5 seconds.
2. An hour glass is displayed on the status bar.
3. The screen dump is saved in the file system as a .jpg file. It is named with current date and time. Select to open saved files. *See "Measurement file handling" on page 8.*

Measurement file handling

Save file

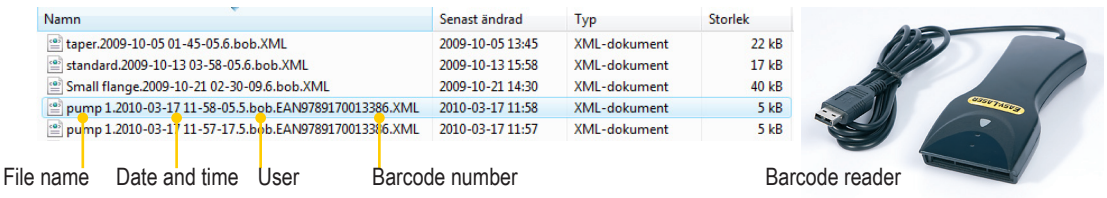
1. Select and to save your measurement.
2. Enter a file name. The date and time will automatically be added to the file name. The measurements that you save will be available to other users as well.
3. Press **OK** to save the file.

Save file with barcode

The barcode scanner is not included in all systems. The first time you measure a machine, you stick a barcode on the machine and save the measurement together with the scanned barcode. Next time you align the same machine, all you need to do is scan the barcode and all machine data is read.

1. Scan the barcode on the machine.
2. Enter a file name.
3. Press **OK** to save the file. All measurement data is saved together with the barcode.

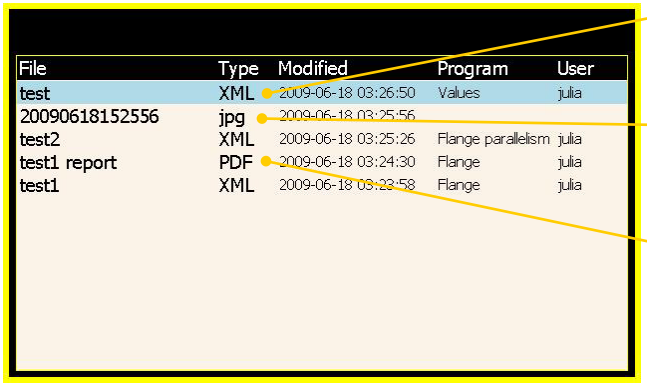
The barcode number is added to the file name. When you connect the Display unit to a PC the whole file name is shown:



Open file

Select (found on the start view and Control panel) to open saved measurements. The File manager is displayed. Here you can easily see who has saved the file, when and from which program it was saved. You see files saved by all users.

PDF is not available for E420.


File Type Modified Program User
test XML 2009-06-18 03:26:50 Values julia
20090618152556 jpg 2009-06-18 03:25:56
test2 XML 2009-06-18 03:25:26 Flange parallelism julia
test1 report PDF 2009-06-18 03:24:30 Flange julia
test1 XML 2009-06-18 03:23:58 Flange julia

xml
A measurement file. Select a file and press **OK** to open.

jpg
A screen dump.

PDF
A report. The PDF report can not be opened in the Display unit.

Open file with barcode

- Start the Display unit and scan the barcode. The **latest** measurement that was made and saved with this barcode is automatically opened.

  OR

- Select to open File view. Scan the barcode on the machine. **All** measurements saved with this barcode are shown.

Open file as template

You can open a saved measurement and use it to make a new measurement. This is very useful when you have many flanges or machines with the same dimensions for example. This way you do not have to enter the same distances every time.

1. Select (found on the Start view and Control panel). The File manager is displayed.
2. Select a file in the list and select . The Edit distance view is displayed.
3. Change distances if needed and proceed to measuring view.

Copy file to USB memory

You can easily copy a saved measurement or other files to a USB memory.

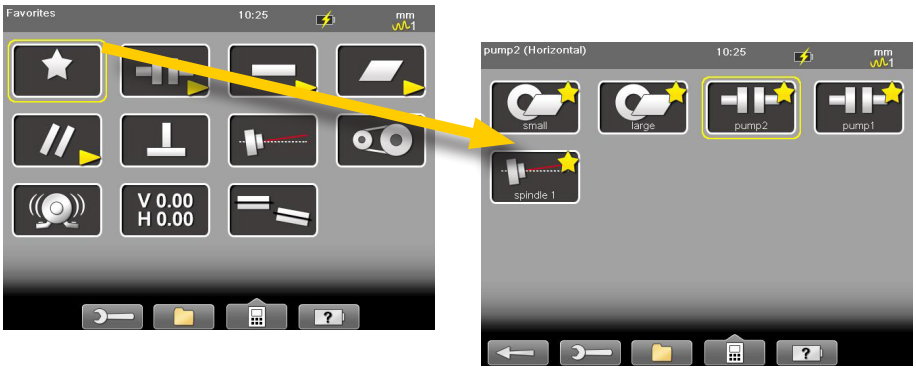
1. Insert a USB memory.
2. Select . The File manager view is displayed.
3. Select the file you want and select .
4. A folder is automatically created on the USB memory. The file is saved in the folder `\Damalini\archive\`.

Favourites

It is possible to save a measurement as a Favourite. A Favourite can be used for example when you have many flanges or machines with the same dimensions. This way you do not have to enter the same distances or tolerances every time. When you have saved as Favourite, a new icon is displayed on the start screen.

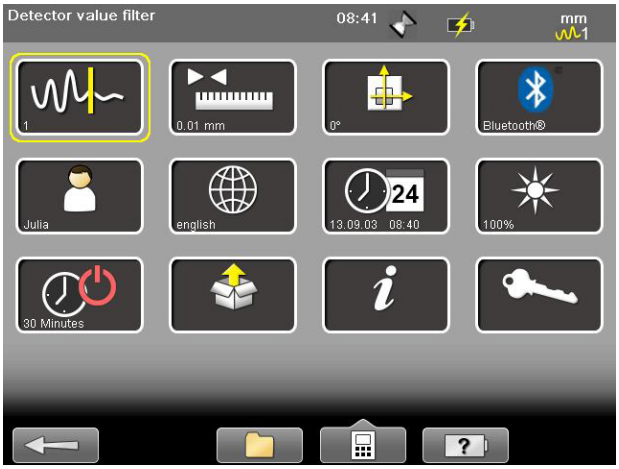
Create a favourite

1. Select to open the File manager and select a file.
2. Select and to save the selected file as a Favourite.
3. Go to the start screen and select to see all favourites.
4. Press OK to open a Favourite. All distances are filled in.



Control panel

Select and to open the Control panel. Some of the settings are personal and will be default next time you start the system.



Note!
All settings are not available for all systems.

Note!
Below some of the settings are described. For a complete list, see your manual.

Filter

Select to open the Filter view.

The filter you select on the Filter view will be saved as a personal setting.

If the laser beam passes through air with varying temperature, this may influence the direction of the laser beam. If measurement values fluctuate, this could mean unstable readings. Try to reduce air movements between laser and detector by, for instance, moving heat sources, closing doors. If the readings remain unstable, increase the filter value (more samples will become available to the statistical filter).

Select filter

Use as short a time as possible that still produces acceptable stability during the measurement. Default is set to **1**. Normally you will use a filter value of 1-3. If you set the filter type to 0, no filter will be used.

Use the numerical buttons 3, 6 and 9 to set the filter. In the Filter view but also when you are using a measuring program.

Unit and resolution

Personal setting

Select to open the Units and resolution view. Use the navigation buttons to move between the fields. Set Metric or Imperial and which resolution you want to use. Default is set to 0.01 mm (0.4 mil). The selected unit is shown on the Status bar.

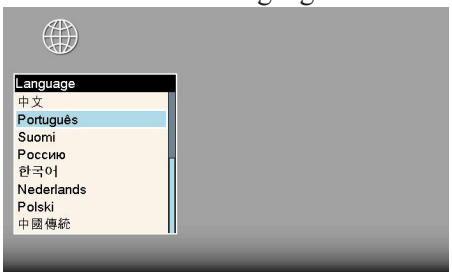
Note!

It is possible to select 0.0001mm only in the E940 system. For E420, only 0.01mm is possible.

Language

Personal setting

Select to open the Language view. Default is set to English. Use the navigation buttons to select a language. Press **OK** to save changes.

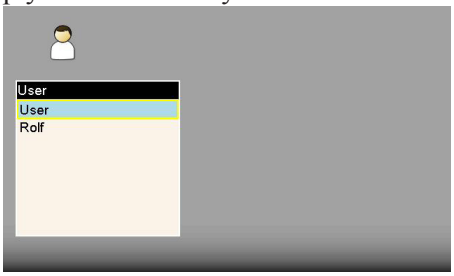


Language view

User

Select to open the Users view. A user account is used for storing your personal settings.

Use the function buttons to add or remove users. To switch user, simply select the user you would like to switch to and press **OK**.

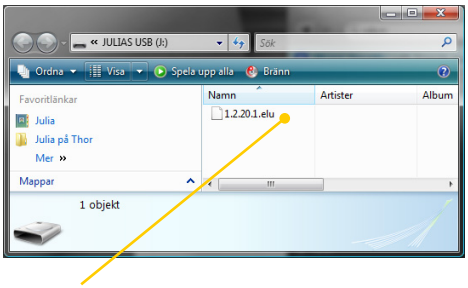


User view

System update

Download update file

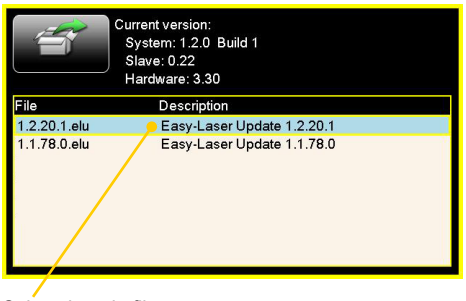
1. Go to www.damalini.com > Download > Software > E series Display unit Firmware Update.
2. Download the update file to your PC.
3. Unzip the file.
4. Copy the .elu file to the root of a USB memory.



Save .elu file on a USB memory.

Install update file

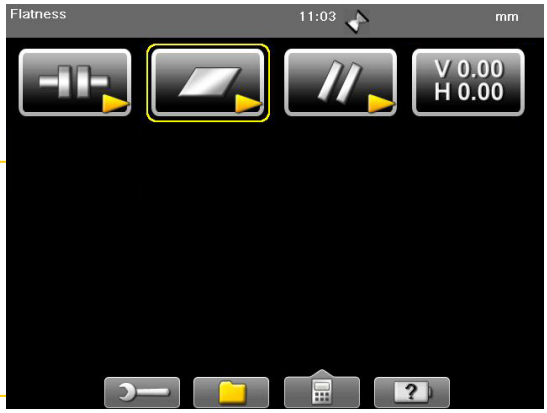
1. Start the Display unit. Make sure that the internal battery of the Display unit is charged. The battery symbol should be at least yellow.
2. Insert the USB memory in the Display unit. Do not remove the USB memory until the update is finished.
3. Select and to display the System update view.
4. Select the update file and press **OK**.
5. Select . The installation starts.
6. The Display unit will automatically restart when the installation is finished and the Main menu is displayed.



Select the .elu file.

Note!

During restart, the screen turns black for up to one minute. When the main menu is displayed, it can "freeze" (no response when you press buttons). If this happens, press the On/Off button for at least 15 seconds to restart the Display unit.



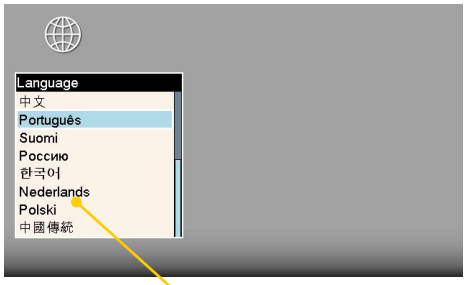
Main menu is automatically displayed after restart.

Font package

Some of the early E-series systems was not installed with Unicode fonts. To install the latest system updates, you need to install the font package with Unicode fonts.

Check if you need to install:

1. Select and to display the Language view.
2. Check if you have Chinese installed. **If Chinese is installed, you already have the correct Font package**. If not, please go to www.damalini.com > Download > Software > Eseries Display unit Font package update and follow the instructions above to install.



Chinese installed?
No need to update with Font package.

Bluetooth®

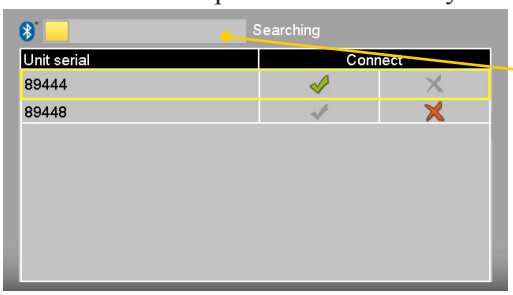
Bluetooth® wireless technology makes it possible for Display unit and Detector to exchange data without using cables.

Some detectors have built-in Bluetooth®, others have a separate Bluetooth unit that you attach to the detector. *Please see Technical data for more information*.

Set up

This is only necessary when adding new Bluetooth® units to the list.

1. Select to open the Bluetooth® view.
2. Select to search for Bluetooth® units.
3. The view is updated with the Easy-Laser® Bluetooth® units you can connect to.



4. Select the unit you want to connect to and select . The unit will automatically be connected when you start a measurement program.
5. Press to save changes and to leave the Bluetooth® view.
6. Enter a measurement program. The Display unit will connect to the selected units. While connecting, the left LED indicator is flashing with a blue light which will turn to a fixed blue light once connected.
7. An icon on the status bar will indicate how many Bluetooth® units are connected.

One Bluetooth® unit connected

Function buttons

	Back to Control panel. Changes made in the table are saved.
	Search for Bluetooth® units.
	Cancel search. Use if your Bluetooth® unit is already found.
	Remove a Bluetooth® unit from the list.
	Connect the unit. The unit will automatically be connected when you start a measurement program.
	Disconnect the unit. The unit will still be in the list.

Use only one Bluetooth® unit

Many of our systems are delivered with two Measuring units. In some cases you might want to use only one unit together with a laser transmitter. By default both units are set to “Connect ✓”. If the unused unit is set to “Connect ✓”, the system will keep on trying to connect to it, even if it is not plugged in.

1. Attach the Bluetooth unit to the detector.
2. Select to open the Bluetooth® view.
3. Set the Bluetooth® unit you want to use to ✓.
4. Make sure that the other units are set to ✗.
5. Enter a measuring program.

The Display unit will connect to the selected unit. This may take a couple of minutes.

Note!

Remove Bluetooth® unit from the Measuring unit before putting the equipment in the carrying case. If attached, it will discharge the Measuring unit.

Bluetooth® information

This device contains

FCC ID: PVH0925

IC: 5325A-0925

This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions;

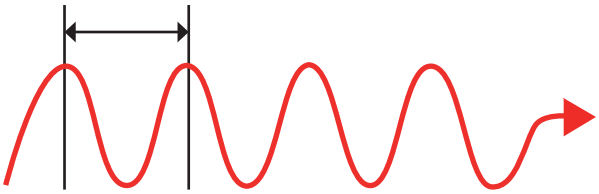
(1) this device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

LASER THEORY

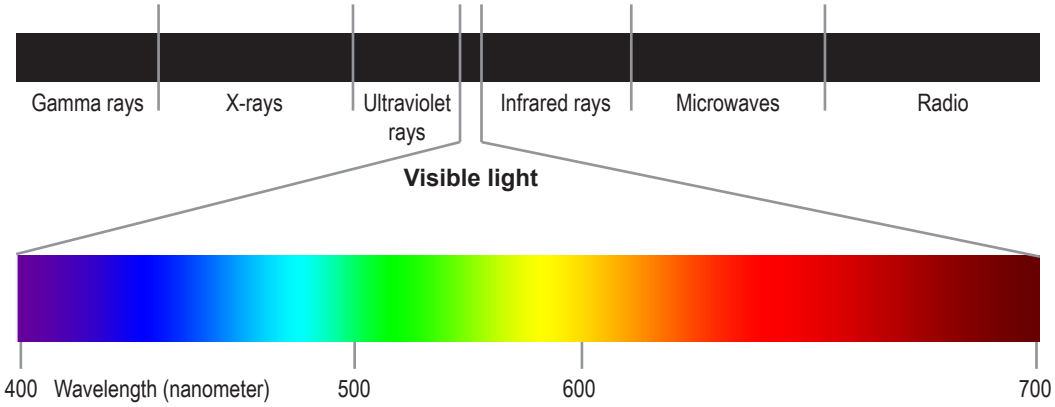
The electromagnetic spectrum contains radiation of many different wavelengths. The radiation is commonly modelled as “waves” that travel through space. The wavelength is the distance between two adjacent peaks on the wave. The spectrum ranges from radio waves, with wavelengths of 1000 m or more, through microwaves, infrared light, visible light, ultraviolet light, X-rays down to radioactive gamma rays at the other extreme, where the wavelength is shorter than 0.01 nm (0.00000000001 m). Light is usually defined as the wavelength range of the electromagnetic spectrum between approximately 10 nm and 1 mm. Visible light is the narrow wavelength region of about 400 to 700 nm, and is the only spectral region that can be perceived by the human eye.

“Wavelength” is the distance between adjacent peaks of the electromagnetic wave.



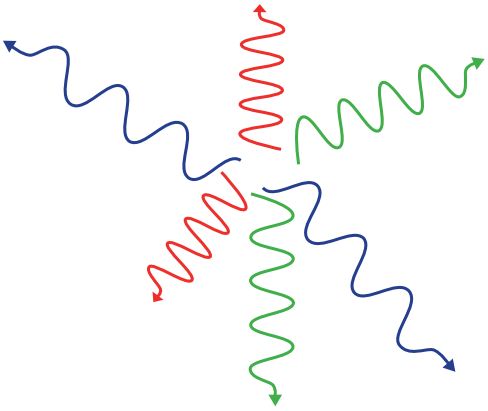
The electromagnetic spectrum

Visible light is a very narrow region of the entire spectrum.

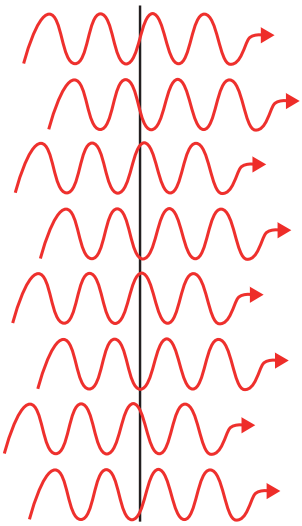


Laser principle

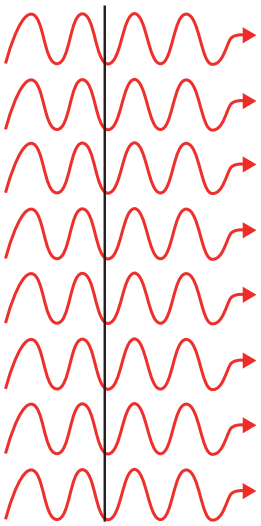
"Laser" is an acronym for Light Amplification by Stimulated Emission of Radiation. This rather complex name refers to the principle of laser light generation, which also gives rise to the special properties of laser light compared to ordinary light. Stimulated Emission means that the light is produced in a kind of "replication process". A medium capable of emitting light is used to this end, and a vast variety of materials can be used for the purpose – gases, liquids or solids. In all lasers, light traveling through the gain medium will produce more light having identical properties – i.e., having the same wavelength, direction and phase. Equal phase of the light means that the wave peaks and valleys are in phase between each light wave.



Ordinary light
Different directions, wavelengths (color) and phases.



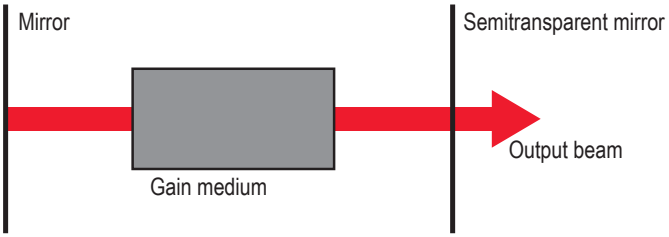
Ordinary light
Same direction and wavelength (color) but random phase.



Laser light
Same direction, wavelength (color) and phase.

Due to the unique properties of laser light compared to ordinary light, a very narrow beam can be formed that has a very low divergence (spread). This is the fundamental fact that makes the laser suitable for measurement equipment.

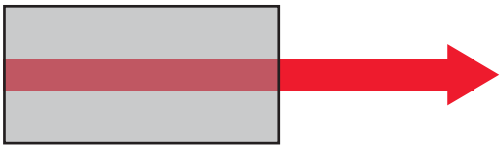
"Ordinary light" – such as sunlight or light emitted from a light bulb – travels in many directions, contains many wavelengths (colors) and has random phase. Even if we construct a light source that emits only red light in only one direction, it is still not a laser, because the phases of the light waves are random. The stimulated emission process is required to give equal phase light! The phrase "light amplification" is also important. In order to produce a laser, the light must be able to travel through the gain medium many times to make the replication process strong enough. The light is amplified during its many round-trips inside the laser cavity. Therefore, "mirrors" are placed on each side of the light emitting material. One of the mirror is made semitransparent. The output laser beam is the light that "leaks" out through the mirror.



A simple laser, having a gain medium (gray) where light is produced, and two mirrors make the light travel back and forth through the gain material. The output beam is the light that leaks trough the right mirror, which is slightly transparent.

Semiconductor laser

Today, the most common laser type is the semiconductor laser diode. A laser diode can be made very small, and the wavelength can be chosen almost arbitrarily within the ultraviolet, visible or infrared range. Diode lasers are extremely reliable and are suitable for mass production. In a diode laser, usually no external mirrors are needed, as the semiconductor gain material itself produces strong reflections at the air/solid interface.



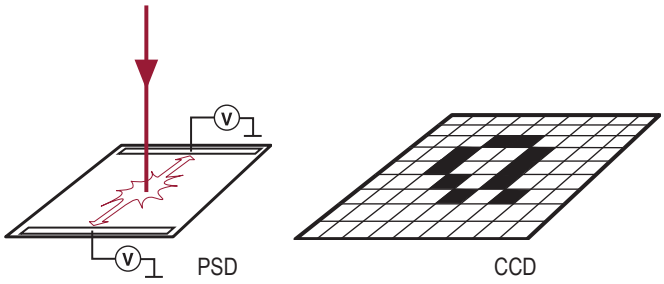
Principle of the semiconductor laser. The air/semiconductor interface give reflections strong enough to act as mirrors. No external mirrors are needed.

Semiconductor diode laser mounted inside a protective housing.

PSD

PSD is short for Position Sensitive Device. The PSD detector consists of a light-sensitive silicon wafer. For comparison the PSD can be called an analogue component, with essentially unlimited resolution, in comparison to a CCD detector, which is digital and with a resolution limited by the design. When the laser beam hits the PSD, an electric current is produced at the point hit by the beam. The difference between the electric currents at the two electrodes are proportional to the position of the beam. This makes it possible to determine the position of the beam centre. The achievable resolution is extremely good, down to thousandths of millimeters or even better.

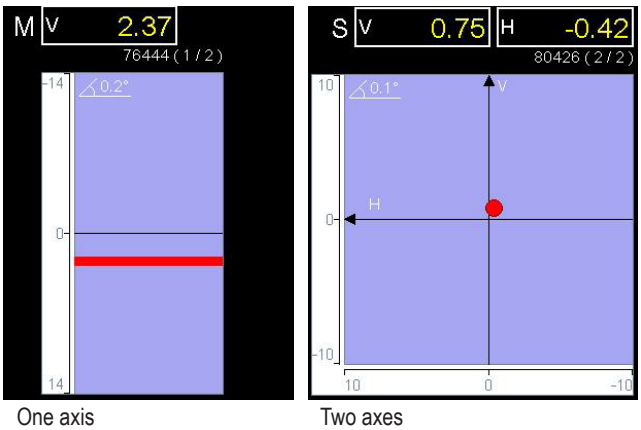
A CCD array (commonly used in digital cameras) is built up of many small elements – pixels – which measure the amount of light entering each pixel. This allows for the beam shape and energy distribution to be measured. A "picture" of the beam can be produced, similar to a digital camera. However, for measurement purposes, the beam shape is not of interest, only the position of the beam on the sensor. If a CCD would be used, tedious data processing would be required to compute the beam center position. Also, the resolution of a CCD is limited to the size of the pixels (usually a few microns at best), whereas a PSD can reach much better resolution. Hence, the PSD is the preferred component for light detection in laser alignment systems, and is used throughout the Easy-Laser® product range.



Easy-Laser® measurement systems use a visible red laser beam as measurement reference. The laser beam is directed onto the PSD detector. Then the measurement programs in the Display unit calculate the values from the PSD and present the result according to which program is used.

One vs two axes

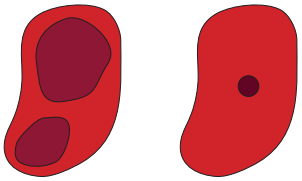
If we move a one-axis detector, we can only measure the change in laser position in one direction (usually the change in height on the PSD). With a two-axes detector it is possible to measure both X and Y axis at the same time. This is a great advantage for many types of measurements.



One axis Two axes

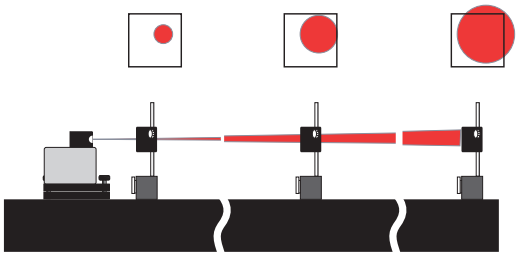
Energy centre

No laser beam is perfectly round. The energy from the beam is also somewhat different over the surface. An accurate measurement result is obtained because the detector reads the energy center of the beam and not the beam shape. As mentioned earlier, this is a clear advantage for the PSD compared to a CCD-based detector.



Divergence and focusing

It is important that the entire beam hits inside the detector surface. If the beam partly falls outside the PSD, a measurement error will result. It is the size of the detector surface in combination with the laser beam divergence that limits the possible measurement distance.

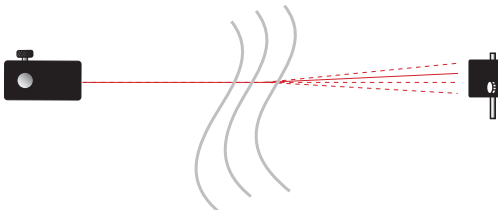


Every laser diverges which means that the beam diameter increases with the distance. At some distance, the beam diameter will be larger than the PSD, and measurement precision is then reduced. A laser can be made to diverge less than 1 mrad, i.e., the beam diameter increases <1 mm/m. Semiconductor lasers are made with collimator optics in order to reduce and control the beam divergence. The laser beam can then be focused at a specified distance.

Poor collimation, and optimum collimation, respectively. The beam focus is placed at an optimum location by means of the collimating optics, leading to a useful measurement range of many metres.

Thermal currents

You can easily see the effects of thermal gradients when the air is moving above the asphalt on a hot summer day. If the laser beam passes through air with varying temperature, the direction of the laser beam may be altered. During continuous measurement this could mean unstable readings. Reduce air movements between laser and detector by moving heat sources, closing doors etc. Always create a good measurement environment, and if that does not help, use a measurement filter.



Laser classifications

Lasers are categorized in different classes depending on their safety aspects. The classification system is rather complex, but the most common laser classes are described below, with typical output power limits and so on. Even for an “eye-safe” laser of class 1, direct staring into the beam should always be avoided.

Class 1

Lasers in this class have very low risk of causing injuries. The risk of eye damage is very low even in the case of long-term direct beam viewing.

Example: Low-power red laser pointer.

Class 2

Easy-Laser® systems belong to Class 2. Low power lasers of visible light, with output generally less than 1 mW. The maximum allowed output is limited so that the natural blinking of the eye stops dangerous radiation when exposed to unexpected laser light. Injuries can only occur if natural reflexes as blinking or turning head away is suppressed.

Example: Easy-Laser® and many other laser measurement instruments.

Class 3B

Lasers in this class are harmful to the eye when viewed directly, but diffuse reflections of the beam from a surface are usually not harmful. Output power can be up to 500 mW for visible light.

Example: Lasers used inside CD and DVD writers, and strong green laser pointers.

Class 3R

Class 3R contains lasers with output power up to 5 mW (visible light). The risk of injuries is still relatively low for a short, unintentional exposure, but the risk increases with exposure time.

Example: Laser scanners.

Class 4

All lasers in this class should be seen as hazardous. Class 4 lasers can burn the skin, and can cause permanent eye damage even from diffuse reflections from the beam. Even faint reflections of the beam can be strong enough to cause fire.

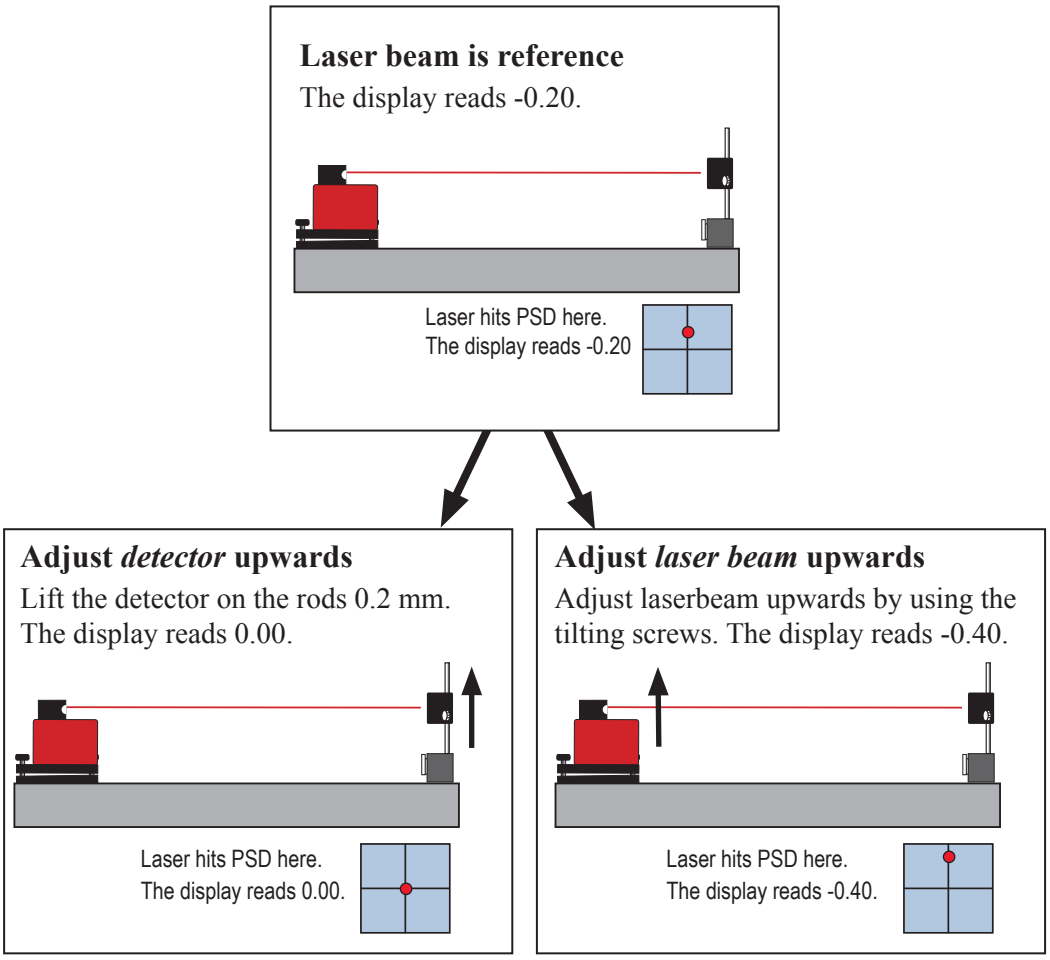
Example: Cutting and welding lasers.

In addition to the laser classes described above, class 1M and 2M exist, which apply to lasers that fulfill Class 1 or Class 2 criteria for a naked eye, but may become unsafe if optical aids are used; for instance a magnifier or binoculars.

Adjust transmitter or detector

The laser beam is reference. Here we explain what happens with the displayed value if you move the laser beam or the detector upwards.

In the following example the laser beam hits the PSD at -0.20.


Laser beam is reference
The display reads -0.20.
Laser hits PSD here.
The display reads -0.20
Adjust detector upwards
Lift the detector on the rods 0.2 mm.
The display reads 0.00.
Laser hits PSD here.
The display reads 0.00.
Adjust laser beam upwards
Adjust laserbeam upwards by using the tilting screws. The display reads -0.40.
Laser hits PSD here.
The display reads -0.40.

SHAFT ALIGNMENT

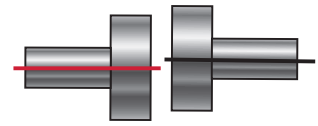
Shaft alignment means adjustment of the relative position of two (or more) coupled machines, for example a motor and a pump, so that the centre line of the axis will be concentric when the machines are running during normal working conditions.

Applications

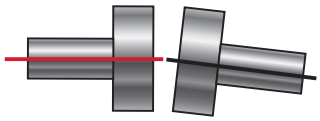
- Pumps
- Motors
- Gearboxes

Misalignments

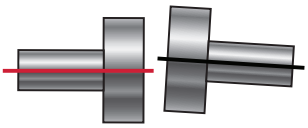
There are two kinds of misalignments, offset and angular. They appear in both horizontal and vertical direction.



Offset
The centre lines of two axis are not concentric but parallel. This is measured at the coupling centres.



Angular misalignment
The centre lines of two axis are not parallel.



Offset and angular misalignment
Misalignment is often a combination of both offset and angular misalignment.

Why align?

Incorrectly aligned shafts and the consequences of this are behind more than 50 % of all malfunctions in rotating machines. This increases unscheduled downtime and therefore production losses. This increases overall maintenance costs.

Correct alignment will give you:

- Less vibration
- Less production loss
- Increased production
- Less bearing and sealing usage
- Less coupling wear
- Lower maintenance cost

How accurate?

The laser measurement system's resolution is 0.001 mm, but the required accuracy depends mostly on the types of machines you have and the speed. Generally speaking, ±0.05 mm for the offset value (at 1500–3000rpm). However, it is important to refer to the machines or component manufacturer's specifications regarding this. That the coupling manufacturer specifies that their couplings can handle an incorrect setting of a few millimetres means nothing regarding how accurately you need to align. This flexibility is to compensate for crooked settings and forces during the start-up phase.

Even when the machine rotates at the correct speed and temperature, it must be correctly aligned. The coupling may last, but seals and bearings are put under pressure by crooked alignment forces and wear out more quickly than necessary. Different couplings cope with misalignments better or worse depending on their design.

A common misconception is that cardan-shaft-coupled machines do not need to be aligned as accurately. But an angular error in these machines causes a non-linear motion, which causes forces and vibrations in bearings, couplings and seals. In other words, shortens the service life. All types of measurements are affected by the environment they are performed in. Regardless of the type of measurement system used. External factors such as temperature, air movement, dust, vibrations and measurement distances all affect accuracy. It is therefore important that the person who carries out the measurement is aware of these factors in order to be able to interpret the results correctly.

Tolerances for shaft alignment

The rotation speed of the shaft will determine the accuracy of the alignment. The table on this side can be used as a guide if no other tolerances is recommended by the manufacturer of the machines. The tolerances is set to the maximum allowed deviation from accurate values, with no consideration to if that value should be zero or compensated for thermal growth.

Offset

	Excellent		Acceptable	
rpm	mils	mm	mils	mm
0000-1000	3.0	0.07	5.0	0.13
1000-2000	2.0	0.05	4.0	0.10
2000-3000	1.5	0.03	3.0	0.07
3000-4000	1.0	0.02	2.0	0.04
4000-5000	0.5	0.01	1.5	0.03
5000-6000	<0.5	<0.01	<1.5	<0.03

Angular error

	Excellent		Acceptable	
rpm	mils/”	mm/100	mils/”	mm/100
0000-1000	0.6	0.06	1.0	0.10
1000-2000	0.5	0.05	0.8	0.08
2000-3000	0.4	0.04	0.7	0.07
3000-4000	0.3	0.03	0.6	0.06
4000-5000	0.2	0.02	0.5	0.05
5000-6000	0.1	0.01	0.4	0.04

Different methods

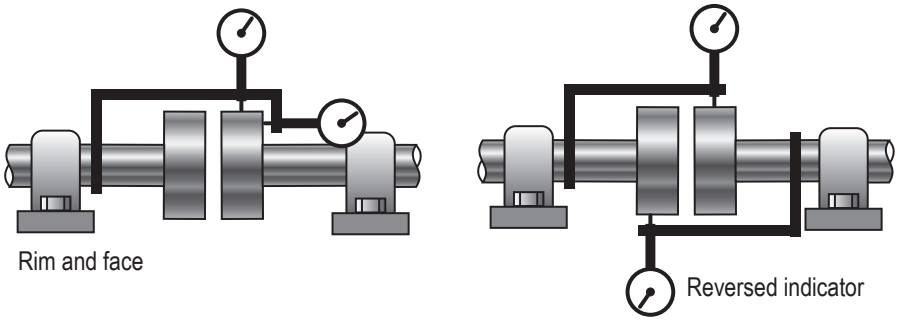
There are many reasons why using a laser alignment is preferable to any of the older methods.

- A laser measurement system can calculate thermal expansion compensation and indicate a good alignment, within the tolerances for the relevant machine.
- Setting up a laser system for measurement on a machine takes a fraction of the time it takes for dial gauges and is much more reliable.
- Gives the same results regardless of who takes the measurements. The possibility of documenting the alignment results gives better control over the machines over time, and therefore greater assurance.

Dial indicators

Dial gauges often require experience and often need complicated calculations.

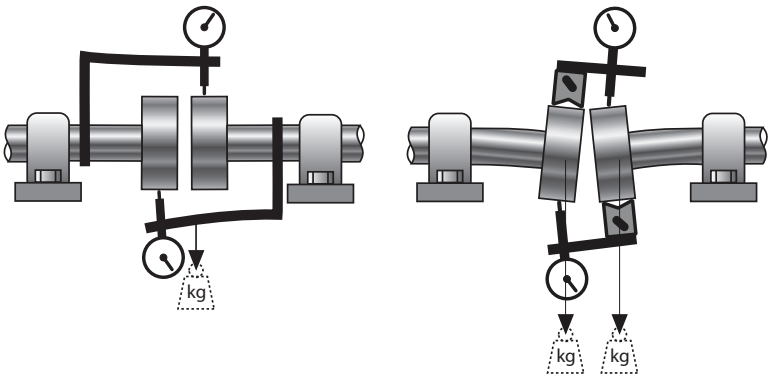
- **Rim and face method**. Two dial indicators mounted on a bracket indicates the offset (rim) and angular error (face) of the coupling. The readings are made when the shafts are turned 180° between positions 6 – 12 and 9 – 3.
- **Reversed indicator method**. Two dial indicators, mounted on each half of the coupling reads the offset and angular error. Measurement values are read when the shafts are turned 180° between the measurement positions 6 – 12 and 9 – 3. One of the dials indicates the offset, and the difference between both of the dials will give the angular error.



Potential errors

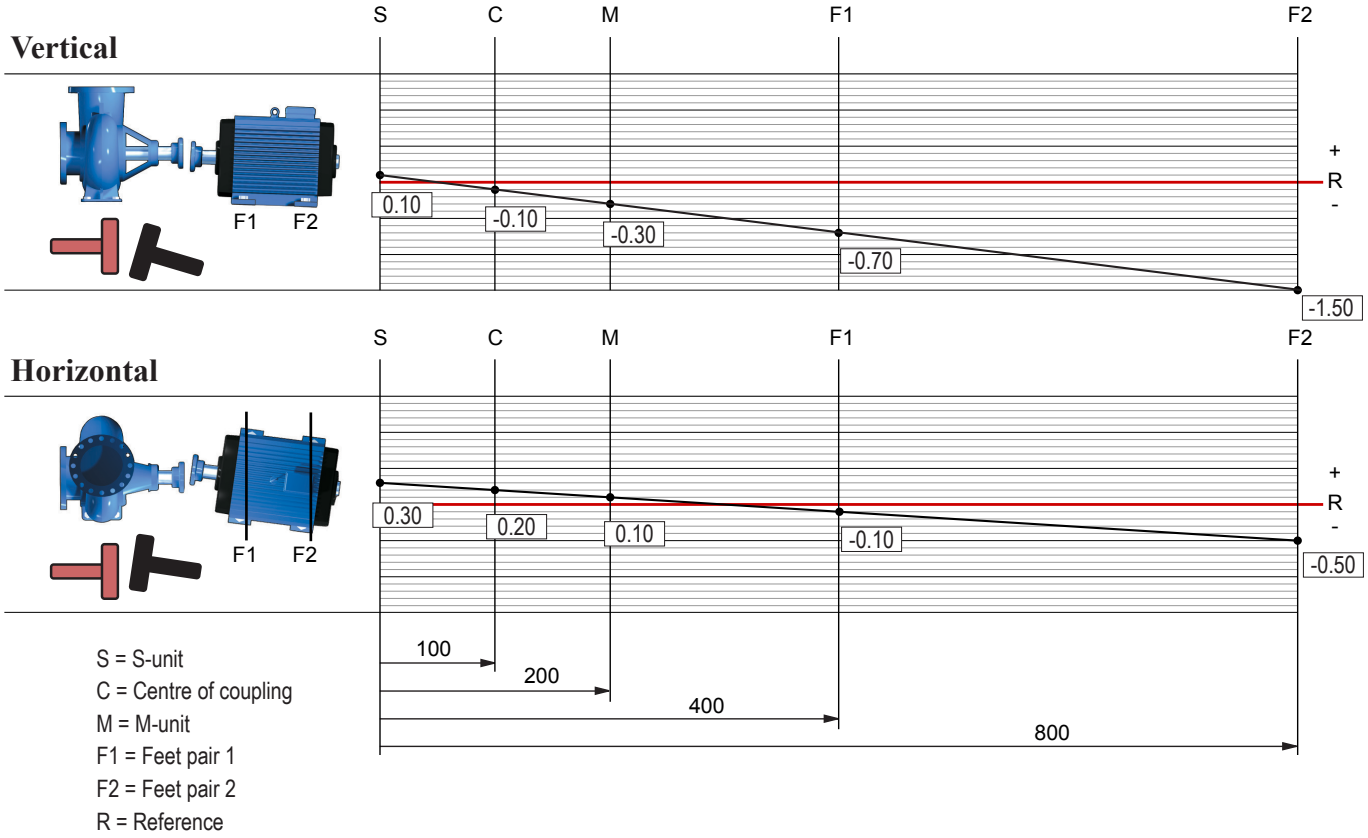
There are several factors that can affect the alignment result when using dial indicators. For example:

- **Sagging brackets**. Brackets for dial indicators always drop a little, which affects the accuracy of the displayed value.
- **Play and clearance**. Play and clearance can also easily occur in mountings.
- **Reading errors**. Indicators often have small scales and are difficult to read in poor light conditions.



Mathematical principle

Shaft alignment with laser is based on normal trigonometry, where the values are calculated by the display unit.



S = S-unit
C = Centre of coupling
M = M-unit
F1 = Feet pair 1
F2 = Feet pair 2
R = Reference

Formula

$$\text{Foot position} = \left(\frac{(M - S)}{\text{Distance S,M}} \times \text{Distance S, Fx}\right) + S$$

$$\text{Angle} = \left(\frac{(M - S) \times 100}{\text{Distance S,M}}\right)$$

$$\text{Offset} = \left(\frac{(M - S)}{\text{Distance S,M}} \times \text{Distance S,C}\right) + S$$

Examples

Using the above formula, the calculations of the above machine would be as follows:

$$F1 = \left(\frac{(-0.30 - 0.10)}{200} \times 400\right) + 0.10 = -0.7$$

$$\text{Angle} = \left(\frac{(-0.30 - 0.10) \times 100}{200}\right) = -0.2$$

$$\text{Offset} = \left(\frac{(-0.30 - 0.10)}{200} \times 100\right) + 0.10 = -0.1$$

For vertical direction

Preparations

Before you start the alignment you have to know how the machines will react during normal working conditions, you make a pre-alignment check. To align machines that are in bad shape, or will move from its position just a short moment after starting them is undone work.

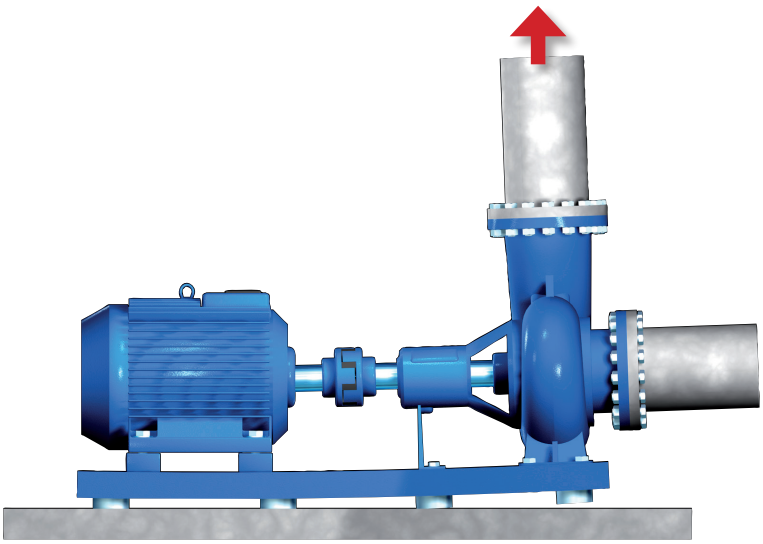
- **General conditions**
  Temperature, vibrations, pipe connections, mounting bolts, coupling and surroundings.
- **Foundation**
  Stable flat and clean. Clean up around and under machinery feet.
- **Machine**
  Is the machine standing unstable on the foundation? Check with Softfoot program.
- **Shims**
  The feet of the machine should not rest directly on to the foundation, instead use bottom shims, for example 5 mm for both stationary and movable machine. Max 4 shims/foot. Are they clean from dirt and rust? Which material, stainless steel, brass or aluminium?
- **Jacking bolts**
  Are there any adjustment screws/jacking bolts? If necessary, mount adjustment screws.
- **Run-out**
  Run-out is measured on the couplings or shafts. Correcting excessive run-out requires replacing the defective coupling or shaft.

Pipe connection check

Perhaps one of the most significant issues that impacts shaft alignment tasks and contributes to misalignment-related machinery failures is pipe strain. Two major types of pipe strain exist, static pipe strain and dynamic pipe strain.

Dynamic pipe strain

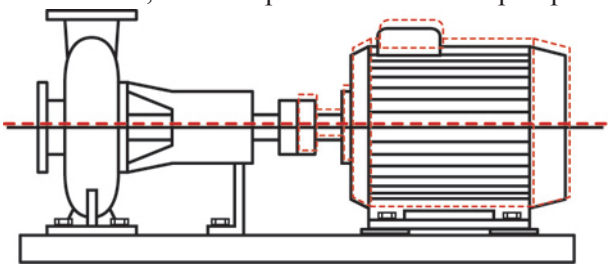
Dynamic pipe strain is much more difficult to check since it is present only after the machine and piping are at operating conditions. Much of this type of pipe strain is due to thermal expansion of the piping, the weight of system fluid, combined with inadequate piping and piping support design. This type of pipe strain is most often detected by using a measurement device to check for machine movement between off-line and online conditions.



Forces in the pipe, pulling the pump and foundation up

Thermal growth

During normal operation machinery will be influenced by different factors and forces. The most notable of these changes is the change in the temperature of the machine bearings and supports. This is called thermal growth and can result in an offset deviation from the position of a ”cold” machine. This new position of the shafts is normally called the ”hot” condition. Depending on what kind of machinery it is, these changes can be of great importance. Note that the ”hot” condition also can cause a shrinking of the machine, for example with cold water pumps.



The machine manufacturers normally provide information about the thermal characteristics of their machines. Always check the following when deciding the influences of thermal growth:

- The working temperature for both machines.
- The temperature coefficient for both machines.
- The influence of the surrounding temperature such as machinery isolation, external heat sources, cooling systems etc.

Thermal changes in gearboxes can be especially difficult to calculate. Often the input shaft temperatures will be different than the output shaft temperatures. This also causes the gearbox shaft alignments to change in the horizontal plane as well as the vertical plane. Force lubricated systems with an oil cooler can also have an effect on the final alignment condition of a machine. Higher oil temperatures out of the cooler will result in a hotter operating condition of the machine. A 5°C change in the operating temperature of a turbine from 40°C to 45°C can change the feet positions by as much as 0.05 to 0.1 mm. The alignment condition of turbines and compressors that operate at very high speeds can be severely affected by these relatively small temperature changes.

Use the program Thermal growth compensation, see product Manual.

Example

The result of the measurement can be influenced from different thermal growth factors for the S- and the M-machine.

- Height from foundation to shaft 1 m
- Temperature when aligning +20ºC
- Working temperature +50ºC
- Thermal growth: 1 x 0.01 x (50-20) = 0.3 mm

There is no problem when the S-machine has the same characteristics as the M-machine. In other cases you have to do the alignment before the machine get cold, or you have to compensate for the difference.

If the S-machine rises with 0.25 mm more than the M-machine as a result of the thermal growth, the shims under the M-machine also has to be increased with 0.25 mm (under all feet).

Temperature growth coefficients

Steel	0.011 mm/m/°C
Iron	0.011 mm/m/°C
Aluminium	0.024 mm/m/°C

Equipment

E420

Part no 12-0745

The Easy-Laser® E420 sets a new standard in entry level laser systems for shaft alignment. Wireless measuring units, a large 5.7” colour display and an IP65-rated design that withstands harsh environments. These are the features you would normally only find in more expensive systems!

E420

E530

Part no 12-0695

Easy-Laser® E530 is a very powerful shaft alignment system, with the ideal balance between performance and price.

E530

E540

Part no 12-0775

Easy-Laser® E540 is a very powerful shaft alignment system, with the ideal balance between performance and price. The measuring units are incredibly compact featuring Bluetooth® wireless technology, an integrated rechargeable battery and TruePSD detectors. This means that they are easy to install on most types of machines, even where there is limited space.

E540

E710

Part no 12-440

Easy-Laser® E710 gives you all the functions for shaft alignment plus the opportunity to check the machine base and any bearing play using the standard equipment! Programs for Horizontal machines, soft foot checks, Machine trains, vertical/flange mounted and cardan/offset mounted* machines are included. Furthermore programs for Straightness and Flatness measurement are included. Using accessories you can also align sheaves/pulleys with digital precision and check vibration levels.

E710

Measuring units

12-0434

12-0433

Measuring units used for E710

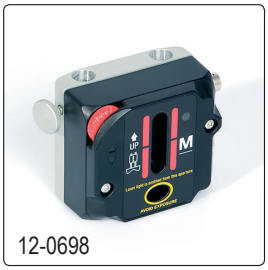
PSD 20x20mm
Two axes
Connectors for cables or Bluetooth® unit.

12-0776

12-0777

Measuring units used for E540

PSD 30mm
One axis
Built-in Bluetooth®



12-0698

12-0697

Measuring units used for E530

PSD 30mm
One axis
Connectors for cables or Bluetooth® unit.

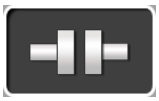
12-0746

12-0747

Measuring units used for E420

PSD 20mm
One axis
Built-in Bluetooth®

Programs included

	E420	E530	E540	E710
Values	*	*	*	*
 Horizontal	*	*	*	*
Vertical	*	*	*	*
Softfoot	*	*	*	*
Machine train (**)		*	*	*
BTA		*	*	*
Vibration		*	*	*
Cardan				*
Straightness				*
Flatness				*
Flange flatness				*
Flange flatness section				*
Twist				*
Offset and Angle				*

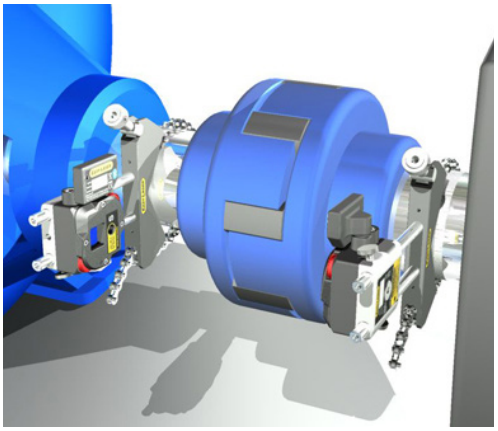
(**) The program Machine train(3) is included in E530 and E540

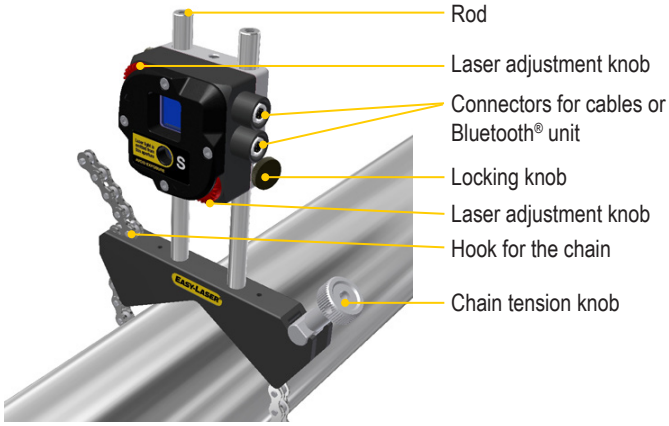
Mount the measuring units

The units can be mounted in many different ways. There are several kinds of brackets: standard shaft brackets, magnet bases and offset brackets for example. All kinds of brackets are not included in the system but can be bought as accessories.

Mount the S-unit on the stationary machine and the M-unit on the movable machine. The measuring units used for E420, E530 and E540 need to be placed with a offset.

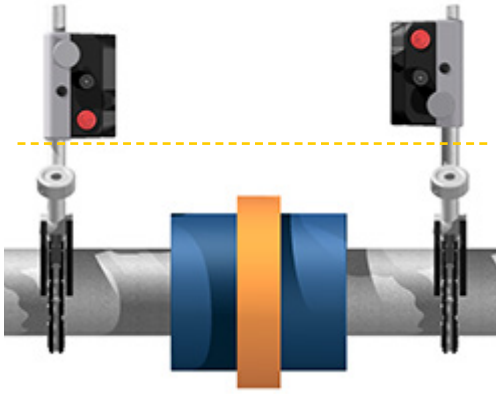
E710

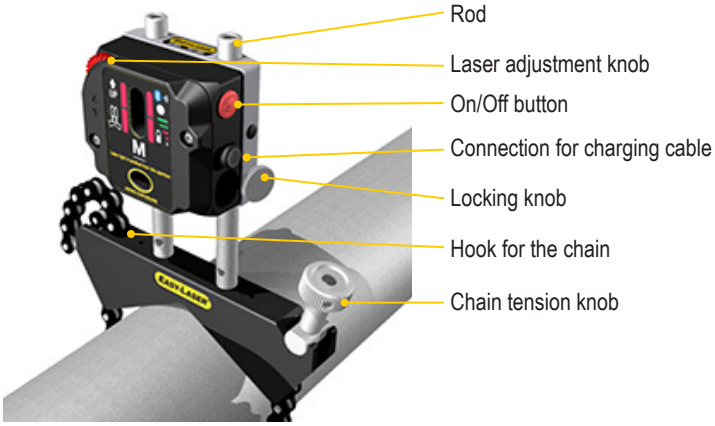




Mounted measuring units

E420

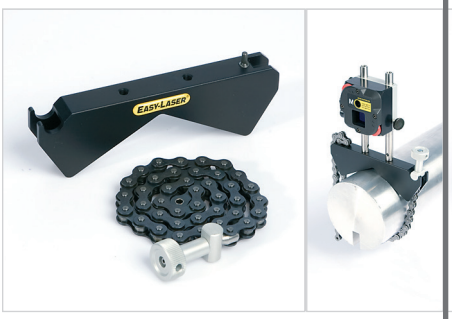




You need to place the measuring units with an offset.

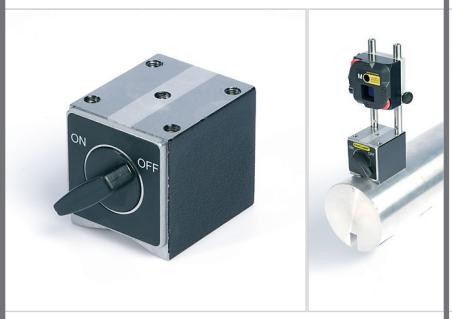
Brackets

SHAFT BRACKET WITH CHAIN



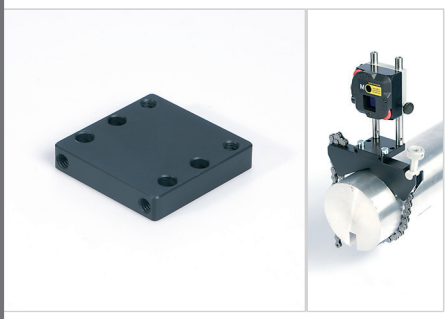
For attachment around shaft or coupling. Suitable for diameters of 20–450 mm [0.8”–17.7”] with standard chains.

MAGNET BASE



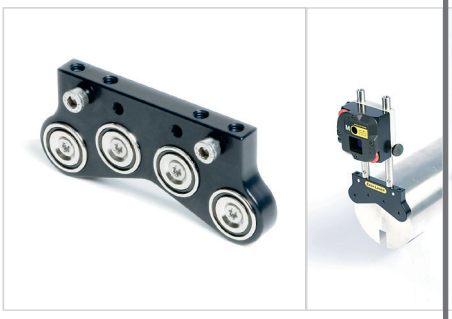
For direct attachment to shaft or coupling. Very strong and stable. Three magnetic sides give flexible positioning possibilities.

OFFSET BRACKET



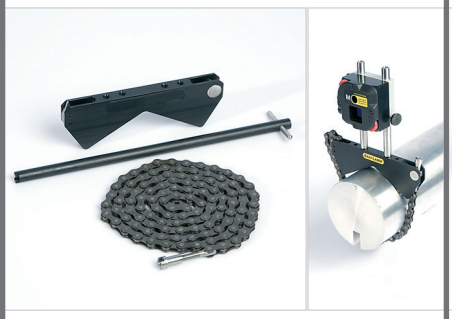
Allow axial displacement between measuring units in order to be able to rotate past projecting machine parts and connectors.

MAGNETIC BRACKET



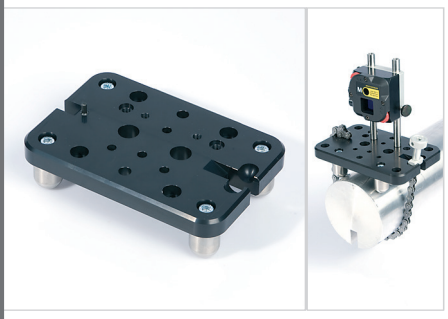
Bracket for axial mounting on flange or shaft end. With four super magnets.
Part No. 12-0413

THIN SHAFT BRACKET



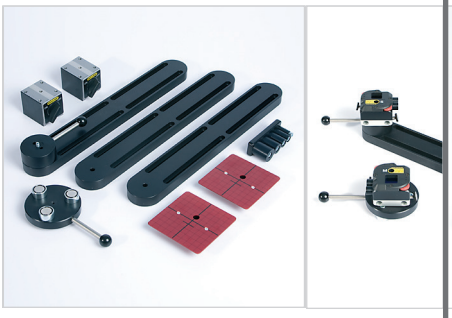
This is used, for example, when there is limited space between the coupling and machine. Thin chain and lock tools included. Width: 12 mm [0.47”]. Part No. 12-0412

SLIDING BRACKET



Used when the shafts cannot be rotated. The spherical feet give a stable position against the shaft. Mounted with standard chains.
Part No. 12-0039

CARDAN BRACKET

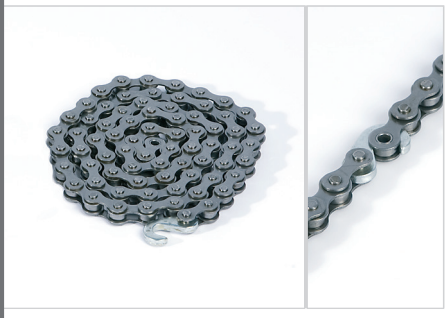


For alignment of Cardan/offset mounted machines. Part No. 12-0615

EXTENSION RODS

Screwed together. Extendable theoretically ”unlimited”.
Length 60 mm [2.36”], (4 x) Part No. 12-0059
Length 120 mm [4.72”], (8 x) Part No. 12-0324
Length 240 mm [9.44”], (4 x) Part No. 12-0060

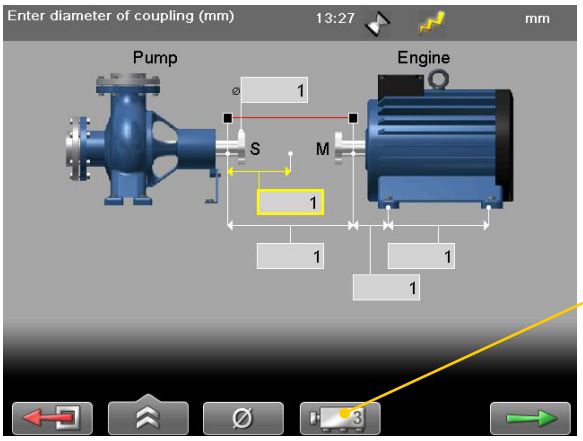
EXTENSION CHAINS



Makes it possible to align very large shafts.
Length: 900 mm [35.4”], (2 x) Part No. 12-0128

Enter distances

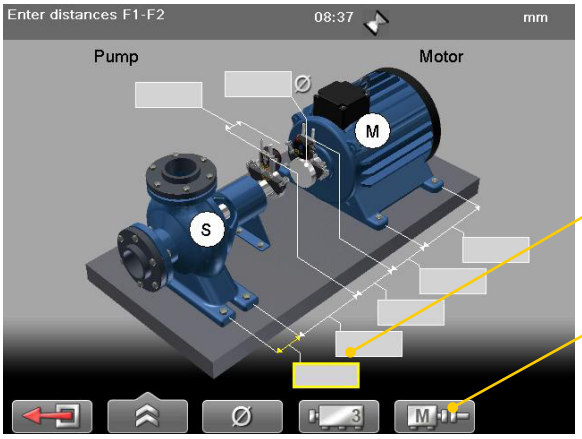
The Enter distance view is different depending on which system you have. Enter the distances and confirm each distance with .



E420

Possible to:

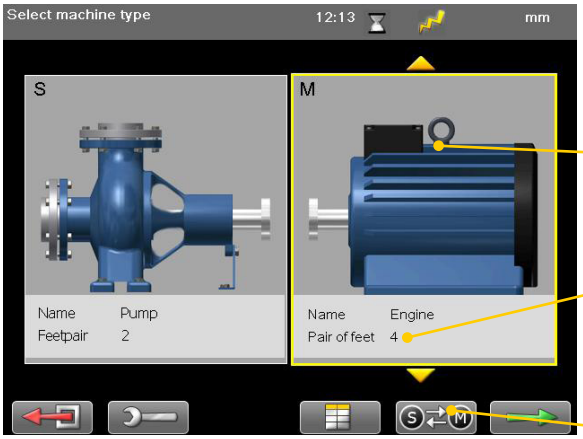
- Select basic set-up with pump and motor.
- 2D view.
- Add a feetpair on one machine.



E530/E540

Possible to:

- Select basic set-up with pump and motor.
- Enter distances on the S-machine.
- 3D or 2D view.
- Add a feetpair on both machines.
- Show movable machine to the left or the right.



E710

Possible to:

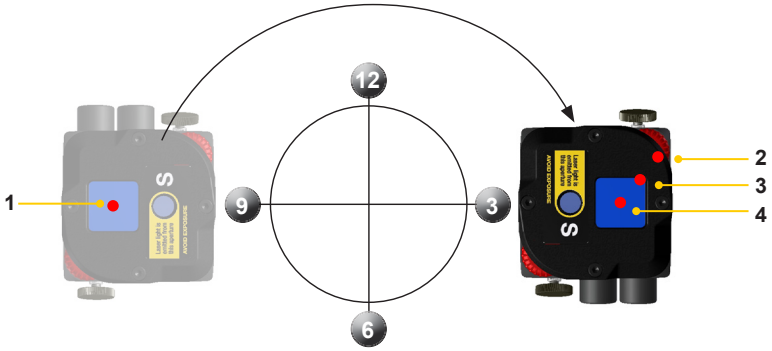
- Select basic set-up with pump and motor.
- Select machine images.
- Enter distances on the S-machine.
- Select 3D or 2D view.
- Define as many feet pairs as you need.
- Rename the machines.
- Show movable machine to the left or the right.
- Switch on which machine you will place the S (stationary) and M (movable) measuring unit.

Rough alignment

When making a new installation, a rough alignment can be necessary. Place the Measuring units on the rods, make sure they are at the approximately same rotational angle and radius. Also make sure that the adjustment knob is adjustable in both directions.

Adjust measuring units (E710)

1. Place the Measuring units at 9 o'clock. Aim the laser beams at the centre of the targets.
2. Turn the shaft to position 3 o'clock. Note where the laser beams hit.
3. Adjust the laser beams half way to the centre of targets. Use the adjustment knobs.
4. Adjust the movable machine until the laser beam hits the centre of targets.



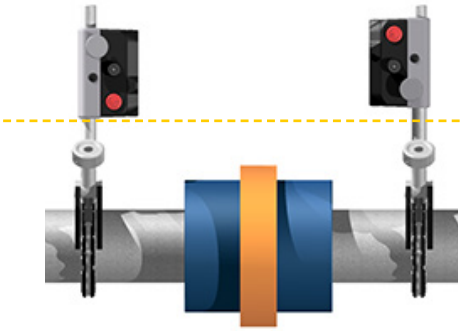
The example shows the S-unit, but the procedure is made on both units.

Note!

This is how it is done for the system E710. For the other systems, see next page!

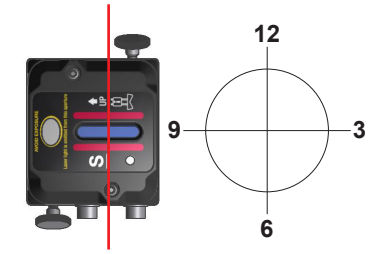
Adjust measuring units (E540, E530. E420)

Place the Measuring units on the rods, make sure they are at the approximately same rotational angle. You need to place the measuring units with an offset. Also make sure that the adjustment knob is adjustable in both directions.

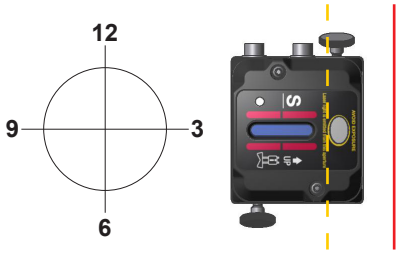


You need to place the measuring units with an offset.

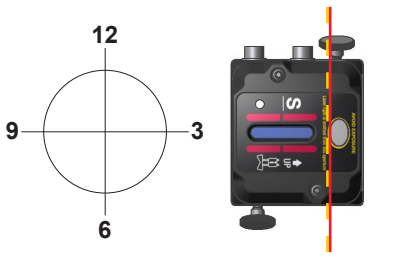
1. Place the Measuring units at 9 o'clock. Adjust the laser line to the centre of both targets. Use the adjustment knob and/or move the detectors on the rods.



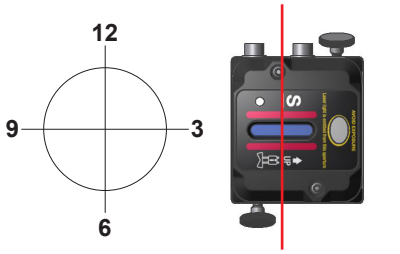
2. Turn the shafts 180º. Make a mark on the rods or machine halfway between the laser line and centre of both targets.



3. Adjust the laser beams half way to the centre of targets. Use the adjustment knobs and/or move the detectors on the rods.

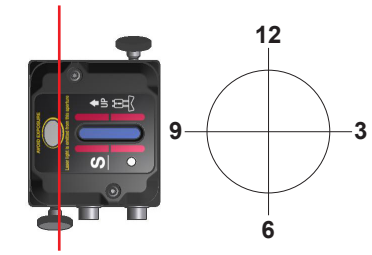


4. Adjust the movable machine until the laser beam hits the centre of both targets.



5. Turn the shafts 180º. Check if both laser lines hit the targets. If not, repeat step 3–5.

Turn shafts to 12 o'clock. Repeat all steps for vertical adjustment.

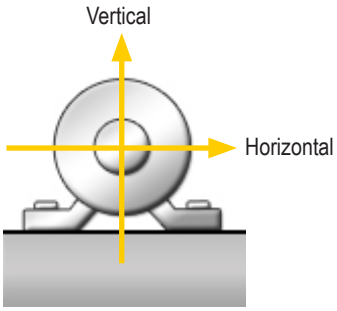


Measure

There are three different methods to choose from.

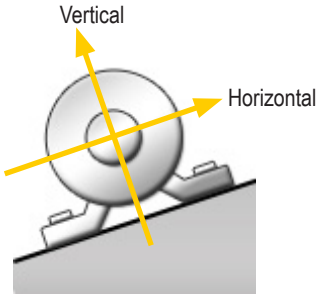
EasyTurn

To be used for all horizontal machines using spirit level as your horizontal reference.



9-12-3

- To be used when your machine's horizontal adjustment is different from the horizontal plane of the spirit level. For example machine tools and spindle to spindle measurement.
- When measuring on a floating object off shore where the horizontal plane is changing. For example ships and oil rigs.



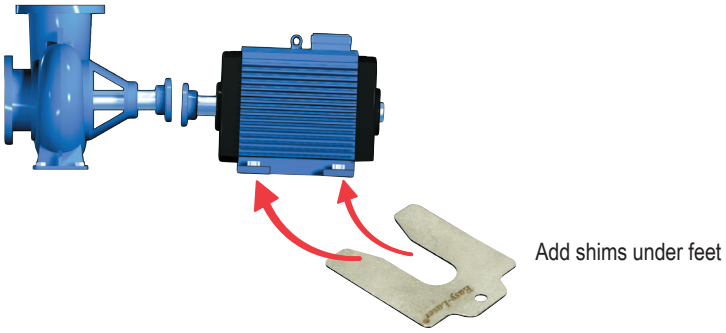
Multipoint

Multipoint is perfect to use for example large shafts. When you are not able to rotate the shafts, you have to rely on the shaft surface. Register many measurements will give you an improved calculated centre. For example turbines.

Adjustment

There are many ways to correct a misalignment. Often you need to correct both vertically and horizontally. Lifting equipment is more difficult than sliding it sideways, so it is desirable to make the minimum number of moves necessary to achieve the correct vertical position.

If good lateral alignment has been achieved, try to keep as many foot bolts tight or have the jackscrews tightened against the machine element to prevent the unit from moving back out of alignment when shims are being added or removed from the feet. Lifting equipment with a couple of foot bolts tightened can be a very delicate and challenging operation and must be performed with extreme caution. The idea is to lift the unit just far enough to slide shims in or out.



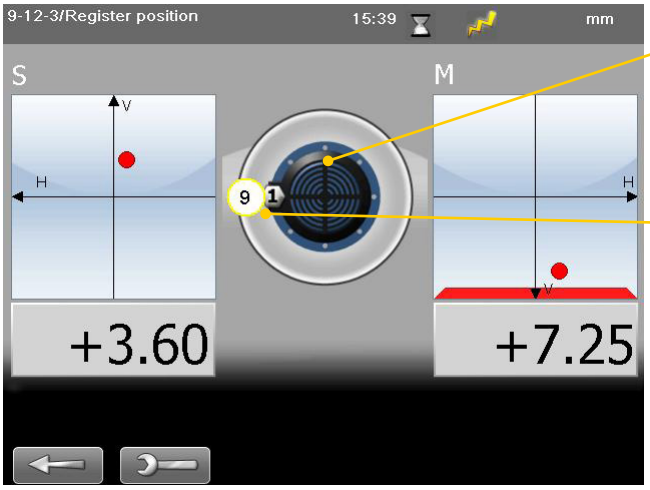
Types of tools

- **Hydraulic jacks**
  When rigged properly, hydraulic jacks provide good control and safety when lifting or sliding equipment and are one of the preferred methods for moving rotating machinery.
- **Permanent jackscrews**
  Jackscrews are the most preferred method for moving machinery.
- **Portable jackscrews and machinery positioners**
  If you have more than one of the same types of pump, motor, compressor, etc., it is recommended that devices be used for your specific application.

Vertical and flange mounted machines

The Vertical program is used for the measurement of vertical and flange mounted machines. Position the measuring units and record the values at positions 9, 12 and 3. The 9 o'clock position is selected at any bolt. Rotate the measuring units a total of 180°.

The program Vertical uses the 9-12-3 method.



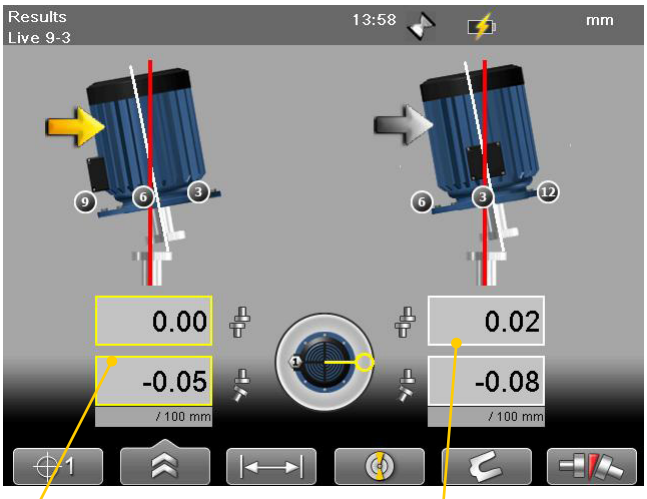
The machine as seen from above.

Circle indicates where to position the S-unit.

Live values in the Result view

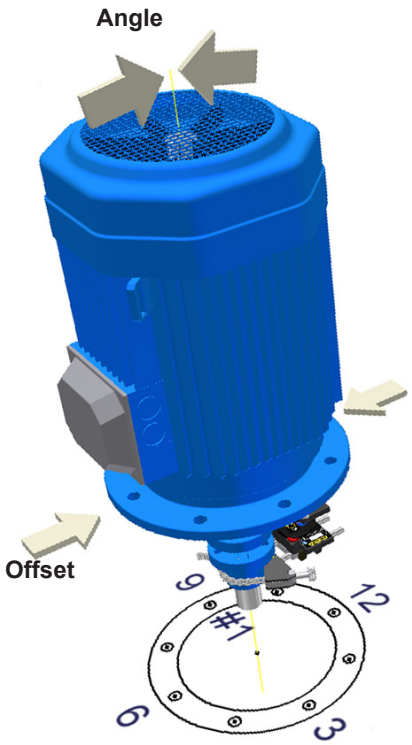
The values can be displayed live in two directions:

- Live in the 9-3 direction.
  Select and position the measuring units at 3 o'clock.
- Live in the 6-12 direction.
  Select and position the measuring units at 12 o'clock.



Live values in the 9-3 direction

Live values in the 6-12 direction



The measuring units at 12 o'clock.
Arrows indicates live values.

Adjustment

Shim the machine first, then do the offset adjustment!

Cardan/offset machines

The Cardan program is used for alignment of cardan-shaft-coupled/centre-offset machines.

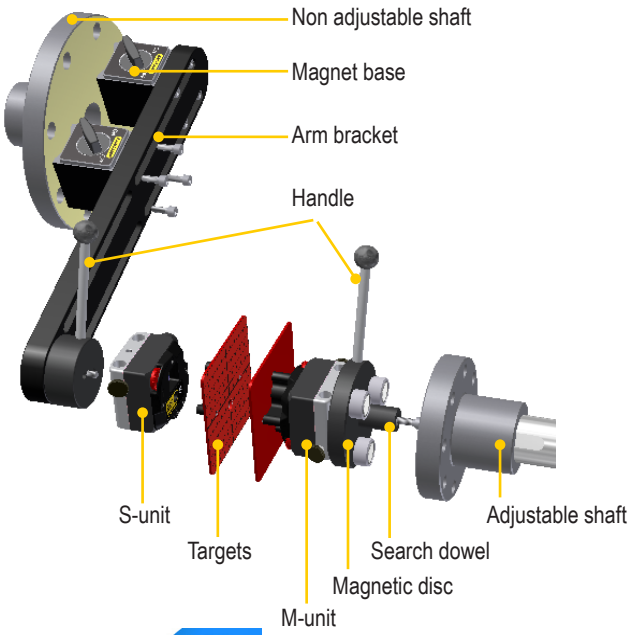
When there are threads at the end of the “movable” shaft, mount guiding pins on the turnable magnet bracket. The guiding pin centres the bracket and permits turning when indexing. Attach the measuring units to the brackets using the central M6-threads.

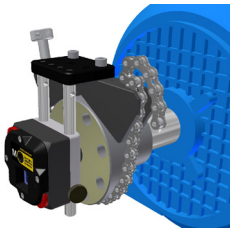
Note!

When the distance between movable (M) and stationary (S) bracket/unit is short (<300 mm), it might happen that the adjustment range in the measuring units will not get the beam to hit within the detector. Then use the M6-thread back at the unit that centres with the laser beam aperture instead.

Mount the units

1. Mount the arm bracket on the non adjustable shaft. You can use the magnet bases or the mount the bracket directly on the flange.
2. Mount the S-unit on the arm bracket.
3. Mount the M-unit on the magnetic disc. If the adjustable shaft has a thread, use suitable search dowel. This makes the centering easier.
4. Mount the targets.





Alternative mounting with offset bracket and chain.

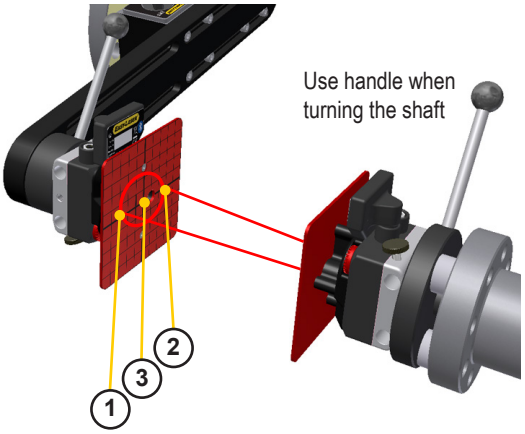
Joined arm brackets for large offset

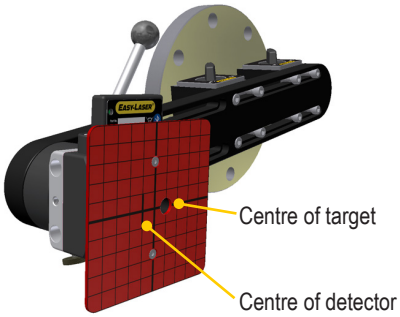
Cone laser beam

When you turn the shaft, the laser beam will draw a circle on the target. If the distance between S and M is small (<300 mm or 12 inch), it can be difficult to cone the laser beam. If this is the case, proceed to *Rough alignment*.

1. Note where the laser beam hit the target at position **1**.
2. Turn one of the shafts 180º. Note the position **2**.
3. Adjust the laser beam halfway towards position **1**, to position **3**.
4. Turn the shaft again. If the laser beam does not move when you turn, the laser beam is correctly coned.
5. Repeat step 2–5 with the opposite unit.

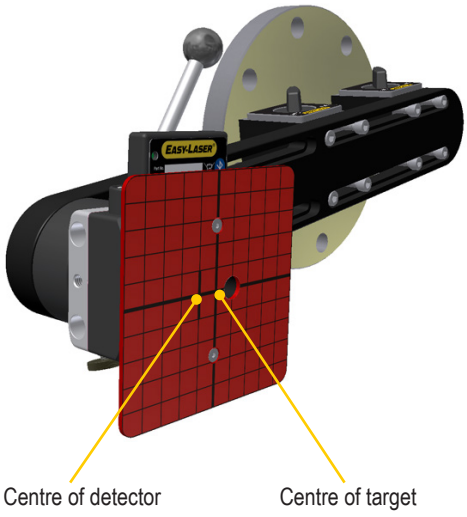
6. Position both units at 9 o'clock.
7. Move the arm bracket until the laser hits the centre of the target on the M-unit.
8. Adjust the S-unit laser beam until it hits the centre of the detector. Adjust using the red screws.
9. Adjust the arm bracket until the laser from the M-unit hits the S-unit in the centre of the target.
10. Adjust the laser beam on the M-unit until it hits the centre of the detector.
11. Remove the targets.





Rough alignment

1. Adjust the arm bracket until the laser beam from the M-unit hits the centre of the target.
2. Adjust the movable machine until both laser beams hit **centre of the targets**.
3. Adjust the arm bracket if the adjustment of the machine is not enough.
4. Turn the shafts to 9 o'clock.
   Connectors pointing upwards.
5. Adjust the laser beams to the marking for **centre of detector**.
6. Remove the targets. The Display unit shows the position of the laser beams.



Machine train

For alignment of machine trains. You can pick the reference machine manually, or let the program choose one that will minimize the need for adjustments.

There are two types of Machine train programs. The program Machine train(3) contains limited functionality. It is delivered with the E530, E540 and E580 systems.

Note!

The Machine train program is not included in the E420 system.

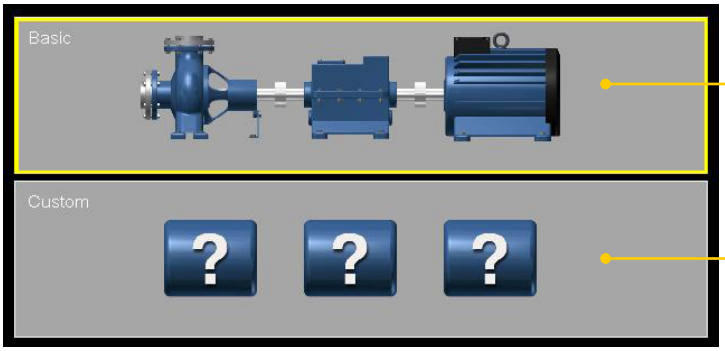
Custom train

This option is *not* included in the Machine train (3) program.

Select this option if you want to build a custom machine train. You build the train from left to right. There are several machine types to choose from and you can add as many as you need to your machine train. You can also define as many feet pairs as you need on the machines.

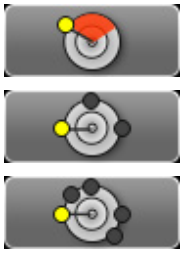
Basic train

The basic machine train contains a pump, a gearbox and a motor. These three predefined machines all have two feet pair each.



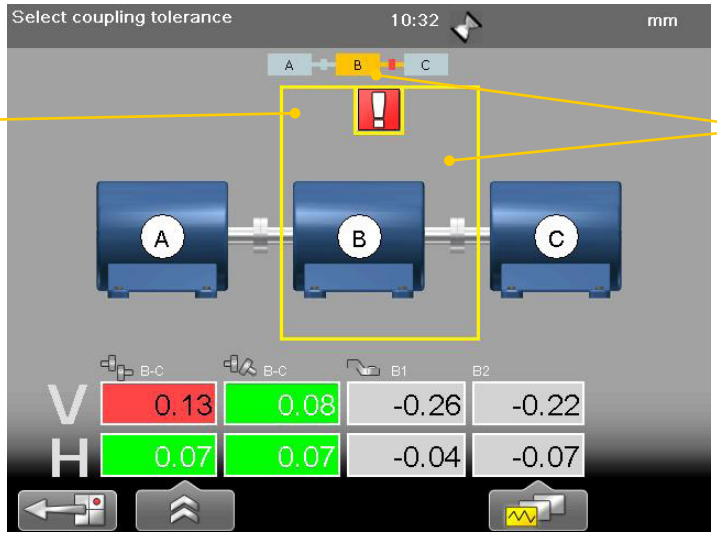
Measure

You can measure the machine train using EasyTurn, 9-12-3 or Multipoint.



Result

You can show the result as graph, table or machine view.



Questions Shaft

1. Which parameters do you need to calculate thermal growth?
2. How large will the offset caused by thermal growth be if the height from foundation to centre of shafts is 1.0 m, the operation temperature of the stationary machine is 100° and for the adjustable machine 50° (material steel)?
3. How accurate do you have to enter the distances?
4. Why do you perform rough alignment?
5. What would you do if there is not enough shaft exposed to mount the brackets on the shaft?
6. Can you mount to the shaft on one side of the coupling and to the coupling hub on the other?
7. Will your readings be less accurate if you mount on the coupling hubs?
8. What happens with the measurement result if you place the S-unit on the movable machine (M) and the M-unit on the stationary machine (S)?
9. What happens with the measurement result if you mount the S- and the M-unit upside down?
10. In which direction (horizontal or vertical) will the centre of two coupled shafts offset to each other, when expanding because of thermal growth?
11. When do you use the program Horizontal, and when do you use EasyTurn?
12. If you measure a flange mounted machine, can you choose an arbitrary bolt as position 9 (bolt no. 1)?
13. When measuring a vertical mounted machine we can’t use the inclinometers as references for positions 9, 12 and 3. What could then work as references instead?
14. What is the main parameter to align to improved tolerance.

NOTES